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ABSTRACT

Summaries are presented of five conference papers on communication, control, and computer access for handicapped individuals. Papers have the following titles and authors: "Accessibility of Graphically Based User Interface Computer Systems for Individuals with Visual Impairments" (Charles Lee and Gregg Vanderheiden); "Data Base vs. Information Base: Preliminary Analysis of a Computerized Information Base in Rehabilitation Technology" (Roger Smith et al.); "Multi-Access Rehabilitation Technology Information Network: MARTIN" (Gregg Vanderheiden); "One Screen Multiplexed Keyboard for Transparent Access to Standard IBM PC Software: (Jon Gunderson and Gregg Vanderheiden); "Accessibility of OS/2 for Individuals with Movement Impairments: Strategies for the Implementation of 1-Finger, Mousekeys, and Software Keyboard Emulating Interfaces Using Device Drivers and Monitors" (Charles Lee and Gregg Vanderheiden). (DB)

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Trace-Authored Papers from the Eleventh Annual Conference on Rehabilitation Technology

Borden, P.A., Gunderson, J., Lee, C.L., Smith, R.O., & Vanderheiden, G.C.

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Table of Contents

Page

Accessibility of Graphically Based User Interface 1

Data Base vs. Information Base 3

Multi-Access Rehabilitation Technology 5

One Screen Multiplexed Keyboard 7

Accessibility of OS/2 9

ACCESSIBILITY OF GRAPHICALLY BASED USER INTERFACE COMPUTER SYSTEMS FOR INDIVIDUALS WITH VISUAL IMPAIRMENTS

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OVERVIEW OF THE PROBLEM

Graphically based user interfaces are becoming the standard user interface for computers. This is evident in the move over the last several years in the microcomputer world toward the Windows/Presentation Manager and the Macintosh user interfaces, as well as the popularity of XWindows and NEWS in the mainframe and mini-computer world. In addition, the recently developed Display Postscript makes sophisticated graphics available for the display. The reason for this move toward a graphical user interface is because it provides a better interface medium for the majority (i.e. sighted) of people.

Graphical user interfaces also help individuals with some visual impairments use computers. They help in that they provide easy software means to enlarge or magnify the screen image for individuals with low vision. The newer operating systems also prevent programs from dealing directly with the video hardware, so adaptive programs designed to give the individual with visual impairments have greater success maintaining a "picture" of the screen.

However, these systems currently hinder the more severely visually impaired individual from using the computer in at least two ways.

First, some of these systems have architectures such that it is not technically feasible for the adaptive programs to gain sufficient access to what is displayed on the screen. There is also currently no way to sufficiently intercept the calls from the application program to the operating system to monitor and reconstruct what is being placed on the screen.

The second and more difficult problem is common to all graphically based user interfaces. Graphical user interfaces (output, input, and control) are designed for the user who has had sight since birth. Individuals who have been blind from birth have a difficult time with the output of these systems. They have difficulty reconstructing a "picture" of the screen because they have different perceptions of the world around them, and often have different conceptualization skills. In addition, the blind individuals are unable to effectively use the input mechanisms, such as the mouse, which rely heavily on continuous visual feedback for effective use. Lastly, the control strategies of these graphical user interfaces depend on the intuitiveness of presenting visual real-life analogies for controlling the computer which are not the same for individuals with visual impairments.

DISCUSSION

The accessibility of graphically based user interface systems can be broken down into two main areas: 1) the technical aspect of providing an operating system which is conducive to allowing adaptive programs/devices to provide the required user interface for individuals with visual impairments (i.e. making it technically easy to connect special alternate input and output devices), and 2) the human factors aspect of the adaptability of graphical user interfaces for sighted persons to an effective user interface for individuals with visual impairments.

The technical features of an accessible operating system

These graphically based user interface systems have bit-mapped screens, and once anything is written on the screen, it is currently only available in bit mapped form. It is therefore important to have the system be able to allow the adaptive programs, for individuals with visual impairments, to intercept the calls to the operating system which draw on the screen so that the adaptive program can identify the words, letters, symbols, etc. as they are being drawn rather than having to deal with only the bit-mapped screen. However, many of the current graphically based user interface operating systems do not allow the application programs and even the special adaptive screen access programs to "know" at all times what is on the screen, or what was recently placed on the screen. Even if they provide access to what is being written on the screen, they sometimes provide too low level of information to the adaptive program, by providing access to only low level drawing commands. For example, the operating system may allow the adaptive program to intercept calls to the operating system to write a dot, draw lines, or bit-blits, but do not let access to the calls to the operating system to draw a box (which is made up of four calls to the line drawing routine) or to draw an irregular polygon and fill it with a certain bit pattern (which is made up of many calls to the line drawing routine, and many bit-blits), or draw a window (which is made up of many functional and visual sub components).

Adaptability of the graphical user interface

The adaptability of graphically based user interfaces to the individual with visual impairments is three fold: output, input and control.

Output: First there are the cognitive and perceptual barriers that exist when trying to get a visual "picture" of a screen (which is normally achieved by processing visual channel) via the non-visual channel (e.g. tactile, auditory, etc.) and with the perceptual skills of the individual.

It is already known that congenitally blind individuals often have different conceptualization skills and do not perceive the world like the sighted individual: They often cannot easily identify objects from different visual perspectives. For instance, even if the blind individual has a tactile outline of a coffee cup viewed from eye level, the congenitally blind individual will not immediately, or ever, recognize it as a cup. But if you give the individual a tactile outline of a coffee cup

viewing it from above, it is easily recognizable. This is because they "see" a cup from above by using their fingers, and rarely try to identify it by feeling it from the side (Ewers 1987).

The congenitally blind individual also has difficulty with visual abstractions of an object. The sighted individual has seen many different trash cans in their life, and is able to somehow sense a visual abstraction of the "generic" trash can. They also have the ability to make the abstraction of this generic trash can into a simple line drawing. However, many blind individuals, even if given a tactile equivalent to a line drawing of a trash can (again as viewed from the side) are unable to easily identify it (Ewers 1987).

Input: The second problem is adapting the input mechanism of the graphical user interface to allow efficient use of these input devices. We normally do not think that the visually impaired user will have problems using the input mechanism of a computer. However, it is quite difficult to separate the user input mechanism from the user output mechanism of the graphic based computers. For example, effective use of the mouse is not just simply a matter of fine motor control of the hand, but includes good "eye-hand" coordination. For the individual who has low enough vision that they require the screen to be magnified eight times (so they can only see one sixty-fourth of the screen at a time), using the mouse can be difficult. For the blind person, it is impossible. But this is only a taste of things to come. There is currently being developed an input mechanism that uses a sensing glove. The computer system is based on a three dimensional display, and instead of a mouse pointer, uses a picture of a hand, controlled by the glove, to serve as the input to the computer system. The user would put on the glove and use their hand to control the hand image on the display in order to manipulate the objects on the screen, or to operate the user interface.

Controls: The third problem is the control aspect of the user interface. Since the user interface is very visual, the control aspects of the user interface will try to simulate real-life situations. We see this already with dragging items into a trash can, or pushing radio buttons. However, the individual with visual impairments has a different set of control strategies and perceptions. As the graphical user interface becomes more sophisticated, providing almost real-life three dimensional displays, this problem may become worse.

The concept of overlapping windows, and bringing a window to the top to make it the currently active window is intuitive for the sighted user. But this control mechanism for selecting the active program or aspect of a program may be difficult for the individual who is blind from birth and who also cannot read braille (i.e. has never had to "shuffle papers") since they may have never developed the concept of having to bring something to the top, visually, to "see" it or work with it.

In addition, since currently most input controls require physical control, and since the visually impaired user cannot rely on visual feedback, the controls for the visually impaired user should incorporate some tactile feedback into the input device. An example would be a force joystick. The visually impaired user could move the cursor or mouse pointer around the screen with the joystick, but the force required to keep the joystick in the current position could be related to the current item under the pointer or the visual items being crossed.

CONCLUSION

The new graphically based user interfaces have provided easier interfaces for the sighted individual. With increased speed and resolution of graphical displays systems, we will soon have more ability to customize the visual interface for the sighted individual. However, we must be very cautious that these new graphical systems and the computers that use them, are not designed in such a way that they cannot be made accessible to the blind individual. These systems should be designed to allow different user interfaces without requiring the application program to adapt. Thus there can be user interfaces to take advantage of the sophisticated graphics of the computer, and others for individuals with visual impairments.

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Inside Macintosh Volume 1-5, Addison Wesley

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DATA BASE VS. INFORMATION BASE: PRELIMINARY ANALYSIS OF A COMPUTERIZED INFORMATION BASE IN REHABILITATION TECHNOLOGY

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Over the past few years both popular literature and rehabilitation technology leadership has documented the need for making information available to those who need it. In 1982, Naisbitt described the increasing societal dependence on information in his landmark book Megatrends. In 1987, the NIDRR mandated that Rehabilitation Engineering Centers must implement information dissemination/utilization activities as a core component of their programs.

In recognition of the need for good information and widespread dissemination, The Trace Research and Development Center has targeted information dissemination as one of its priorities over the past decade. These experiences have provoked a variety of questions and issues. A current critical question is, "How effective are the various methods of implementing information resource programs?" Recently, the Trace Center has re-examined some of its own activities, performed a needs analysis by compiling information requests received at the Center, and assessed a pilot computerized information base with a semi-expert front end.

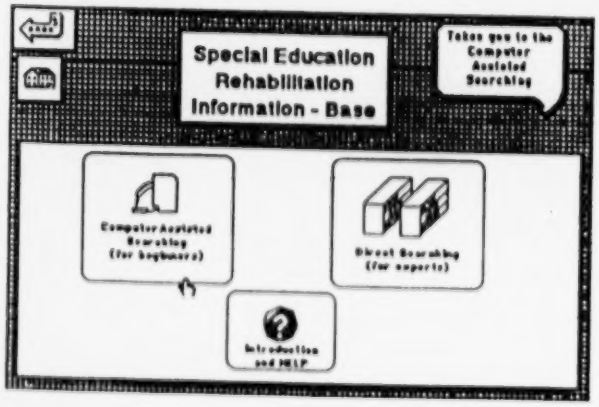
DATABASE AND INFORMATION BASE NEEDS

Analyses of information requests at the Trace Center highlighted the fact that there are three distinct categories of information needs in the field. The first is the type of request which desires an answer to a specific question and is looking for a very specific piece of information or data. For example, many individuals ask where they can obtain a given product and how much it costs. The second type of information need is more investigative. Some users (who are usually already experts in the field) want to know more about a topic. Their need is to browse data as in open reference stacks at the library. The third type of request for information is most general. These are more exploratory in nature. Examples of questions emerging from this type of need are "What would be the best communication system to purchase for a friend of mine who has trouble speaking?" or "Our therapy clinic is going to begin providing some technological types of support services. What do we need to get the program underway?", or "I have a blind child, what should I know about technology?"

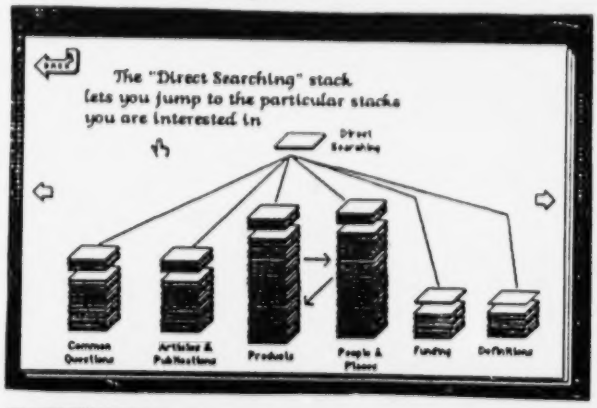
These are substantially different types of needs and consequently require different types of information access. The first requires quick access to a database to recall specific details. The second demands a versatile browsing ability in a wide variety of resources. The third requires a more interactive and probing response to clarify the information needed. The wide variance in questions precipitating from these three needs necessitates a sophisticated system for selecting and dispersing information.

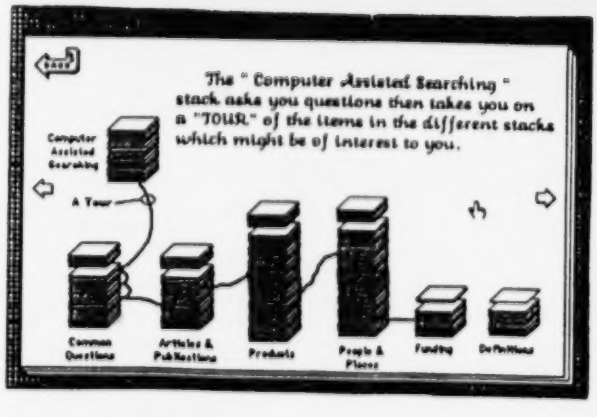
The Trace Center Information Program has implemented several strategies to confront this problem. The Trace Center regularly meet for "Info Rounds", a group information-sharing

Figure 1



Figures 2 & 3




The " Computer Assisted Searching " stack asks you questions then takes you on a "TOUR" of the items in the different stacks which might be of interest to you.
Computer Assisted Searching
A Tour
Common Questions
Articles & Publications
Products
People & Places
Funding
Definitions

and problem solving forum, to discuss the spectrum of questions and requests received, and to allow team members with expertise in different areas to share perspectives. The Center also devotes substantial information personnel time specifically to updating information resources, houses a resource library for staff, and schedules frequent inservices.

However, the efficient identification and distribution of information for a request remains a substantial challenge. This is in part due to the diversity of requests, the limitations of paper file organization schemes, the finite memory of human beings (even experts), and constraints on available personnel resources for in-depth searches.

Consequently, the Trace Center began investigating the possibility of developing a semi-intelligent front-end to its system of information files and databases. Such a system would have to deal with the three types of information requests coming into the Center.

THE INFORMATION BASE

The design team identified that what was needed was not a front-end to a single database, but a front-end to a variety of databases which contained a variety of types of information. The purpose of the front-end, then, was to integrate the set of databases and provide intuitive methods of entering and access information which satisfied the three types of information needs. The design called for was not one of a Database (a set of data in a single organized structure), but an Information Base. This Information Base had to provide a direct "quick find" strategy, a browsing strategy and "question clarification and selection" strategy.

A hypertext data organization was selected to pilot design concepts around this information base. Its flexibility in linking information allows information browsing and seemed conducive to designing parallel access strategies. The Apple Macintosh Hypercard was chosen due to its user friendly visual organization, ease of scripting and availability.

This Hypercard system, which we have called the Rehabilitation and Special Education Information Base, commences with a choice of either a direct searching technique or computer-assisted searching technique. Figure 1 illustrates the base card as well as its intuitive mouse driven format. Each of the squares serves as a "button" which will take the user to the different search methods. (The quotation box in the upper right hand corner provides a help cue as the cursor enters any button).

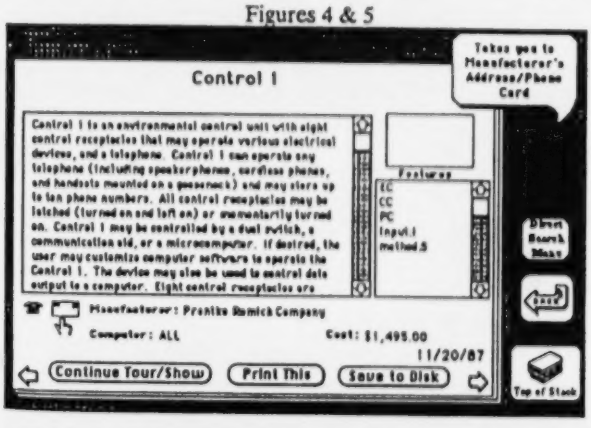
Figure 2 illustrates the card stack system. In this version of the Information Base there are stacks of common questions, articles and publications, products, people and places, funding, and definitions. The direct searching method delivers a user into any stack selected. By contrast, Figure 3 illustrates how the computer-assisted search strategy helps the user clarify the information problem and then takes the user on a tour of all the cards in the different stacks that relate to their question.

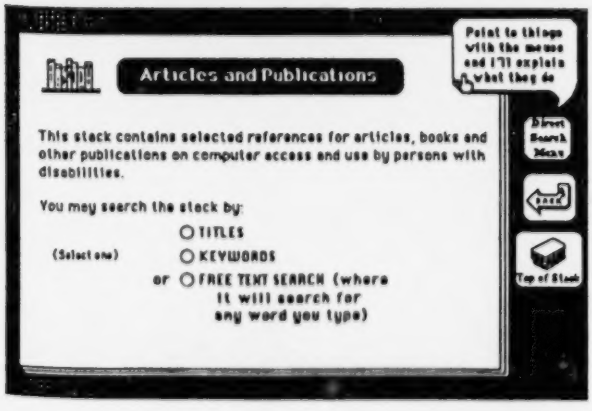
Figure 4 shows an example of a specific data card, a Product entry. Figure 4 is linked to another card in the People and Places stack. Clicking on the mouse with the pointer (the hand) in the position shown takes the user to a card showing the address, phone and other information on the manufacturer of the product. Figure 5 shows the top card of the Articles and Publications stack, which links to specific Reference cards.

This study used the pilot version of the Rehabilitation and Education Technology Information Base, and tested the success of the overall conceptual model. The Information Base was evaluated in two ways. First the development team took actual requests and questions received by the Information Section in dry run. The team also tested the Information Base in real time (a) with actual questions coming into the Information Section on the telephone and (b) with on-site information requests.

This study revealed that the basic design premises of the Information Base appear to hold true. A database should permit "quick find," "browse," and "question clarification and selection" access techniques. Secondly, this study revealed that the human interface to the Information Base was one of its crucial features. The difference between data and information is its availability and applicability to those who might use it. This is dependent on the techniques employed to obtain data.

Figures 4 & 5




Point to things with the mouse and I'll explain what they do
Articles and Publications
This stack contains selected references for articles, books and other publications on computer access and use by persons with disabilities.
You may search the stack by:
(Select one)
TITLES
KEYWORDS
or FREE TEXT SEARCH (where it will search for any word you type)
Direct Search Menu
Back
Top of Stack

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MULTI-ACCESS REHABILITATION TECHNOLOGY INFORMATION NETWORK: MARTIN

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INTRODUCTION

Trying to provide a national central information resource system poses a multitude of problems and contradictory requirements and constraints. In order for the system to be maintained, it must in some way be centralized. In order to be accessible, however, it must be distributed. In order for the information to be easy to search through, it should be organized and presented in a standard format. The diversity of technologies and support materials, however, requires that the formats for the various types of information be different. Creating a unified system speaks to having a central information generation point. Yet the expertise is distributed across centers and groups across the United States, with no one center being an expert or even "very good" at all areas at the same time. Nor does it seem possible to generate such an all-around expert center. Thus, some network of centers is indicated.

If such a system were set up, the best means for accessing the system is also unclear. Novice users and people unfamiliar with computers would like an interface that is very friendly, and that requires no prior knowledge of the system. More expert users, however, will not want to deal with a cumbersome front end, and will want and need direct, fast command-driven access to the data. Individuals having only one or two questions will want a means for accessing the database that requires no equipment. Individuals who have equipment or have large information needs will want to have the fast access and unlimited printout which can only be achieved from an on-site database. Finally, much of the information must be regionalized, particularly in service delivery areas, in order to be useful.

The proposed approach is a coordinated network of specialized information resources which feeds to a central point where the data is available centrally and through distribution of the entire information base to a virtually unlimited number of sites across the country. Further, this information base is multi-access in that it can be accessed through human beings by telephone, directly over phone lines using any terminal (no special software required), through a command-query system, and through an intelligent computer-assisted searching program (that takes a novice user and, by asking question, determines their information needs and then takes them to all the information in the database that is relevant).

ASSUMPTIONS FOR THE INFORMATION SYSTEM

Basic assumptions for this discussion are as follows:

- The database would be placed in a variety of settings, and used by a variety of users, including consumers, parents, friends, rehabilitation personnel, special education personnel, regular education personnel, librarians, researchers, government agencies, funding agencies, dealers, sales representatives, computer training programs, higher education computer resource centers, etc.
- The users will vary in skill from people who are versed in computer use and database searching to people who are afraid to touch the mouse and computer, and don't understand what they're looking at most of the time that they're looking at a computer screen.
- The system should allow individuals to search for a particular item that they know about as well as to dig around to see if there is anything in the database on a particular topic or problem.
- The database should allow them to search by example (e.g., they could look Vista and then ask for other products which are like it or are related).
- The information should be set up in such a way that could be exported to other database formats.
- The contents need to be aimed at different levels of expertise within each of the different user types.
- The database would contain a wide variety of information, not just product descriptions. Some of the types to be included would be:
  1) Product information (description, picture/drawing, manufacturers, cross-linked key words, etc.).
  2) Service centers (regional, national, and local)
     Clinics
     Repair
     Special evaluation (list special evaluation areas)
  3) Training programs (by area, age group, and topic)
     Direct training of consumers
     Training of professionals
  4) Funding information
  5) Information sources
  6) Special interest groups
     Advocacy (UCP, etc.)
     Professional special interest groups (SIGs)
  7) Comprehensive bibliographic information
  8) Selected annotated bibliography of the best documents by topic area
  9) Commonly asked questions
  10) Novices' introduction to various topic areas (which provide a basic orientation to the topic area, as well as acquainting the reader with basic terminology and concerns/issues which they may want to explore; e.g., when looking for a communication aid, when buying a computer, when trying to locate a clinic for special type of therapy, etc.)
  11) State-of-the-art reviews by topic area (documents which gather and integrate the mass of information for a given area into a cohesive and co-

gent whole)

12) Evaluation information by topic area
(which provide a review of the best devices, software, etc. in a given area) (This one could be tricky and expensive -- but is necessary in areas where cost is high or quality varies greatly.)

13) Information on search strategies
(both electronic search strategies and people/ agency search strategies for information that may not be present in this particular database/ information system)

14) Glossary

- The system should capitalize on individuals and programs that want to do and have demonstrated interest in producing information of the form desired. Generating useful information is a difficult and arduous task. Unless people enjoy doing it, they generally will never get around to it. Also, the database/information system will require different types of information and different types of individuals may be best at generating these different types of information.
- The basic structure of the information system should look like a central reference contact point with distributed resource points. The distributed resource points would be housed at centers which specialize in the various areas of expertise (e.g., communication aids, functional electrical stimulation, lower back pain, etc.). The overall information system would contain individuals carrying out five different functions:
  1) library/archival (collecting, filing and tracking of copies of existing documents and reports). This function would also make copies of reports on request (unless copyrighted and in print).
  2) generation of summary and integrative information
  3) handling of specific inquiries (some electronic and some manual)
  4) evaluation of overall effectiveness of the system
  5) research into better mechanisms, features, strategies, etc., for information generation and response
- The central information referral function (3) would handle questions by sending previously prepared information or referring the person to the expert centers for that area. They would not try to generate individual answers for clients. If frequent questions arise, they would be referred to the information generation function for generation of summative information on that topic area. Provision of specific advice on a topic area (when preprinted materials are not available) would be carried out by the individual expert programs for that area.
- Some generation of summative, integrative information would be carried out at the central information center. Most of it, however, should be generated at the expert research points (e.g., the designated REC, R&T, Independent Living, or other center for that topic area).
- Information generated at expert points should include:
  1) summary description of all commercially available products in their area
  2) bibliography of articles
  3) selected annotated bibliography of publications (formal and informal, published and unpublished) which are most useful in studying the area
  4) lists of resource or clinical programs for that area
  5) annual state-of-the-art paper for research in that area
  6) annual state-of-practice paper for products and clinical practices for that topic area
- The data system should provide multiple points and forms of entry. Among those suggested are:
  1) Human on Phone: a phone line which people can simply call and talk to a human being (should have a rehabilitation background and extensive knowledge of the topic area in question)
  2) On-Line Access: a point where people can access the information over telephone lines (using a computer terminal)
  3) On-Site Access: a means for having the electronic portion of the information system available directly on their own computer

     The on-site version of the database overcomes the problem of slow access to information, which is a severe disincentive to using and perusing most databases. Modern technology allows for the dissemination and storage of large volumes of information in a form that is much less expensive than the communication and connect charges associated with long-distance telephone access. In addition, there would be no monetary disincentive for using the system as there is with phone-in systems. Finally, graphic or picture information can be provided which would be impossible to transmit in a timely fashion over phone lines.

     Smaller items (documents) could be directly contained in such an on-site database. Larger items could be automatically ordered by the system from the central information resource point.
  4) Command Access and Guided Access: For both 2 and 3 above, there should be an abbreviated (command driven) and a guided access path to the data. The abbreviated path would allow people who are familiar with the database to access the information very quickly using commands and keywords. The guided interface would allow individuals who were totally ignorant of the topic and the database to be guided to relevant information through the use of a question-and-answer format which they would carry out with the computer.

     This "guided" inquiry process would require the development of an intelligent front-end for the database. A different type of front-end would be required for the central (over phone line) front end than would be required for the on-site front end, due to the difference in communication bandwidth between the two systems.

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ONE SCREEN MULTIPLEXED KEYBOARD FOR TRANSPARENT ACCESS TO STANDARD IBM PC SOFTWARE

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INTRODUCTION

Most of the software available for IBM PC and compatible computers requires information to be entered from a keyboard. People who cannot use the standard keyboard because of physical disabilities are barred from using this software unless modifications are made to the computer system to provide an alternate keyboard. The ability to access this software is very important for people with physical disabilities due to the increasing use of computer systems in educational, vocational, and daily living activities.

One type of alternate keyboard uses the headpointing capabilities of people with physical disabilities. Current headpointing systems for transparent computer access require a separate display for the alternate keyboard. This creates a two-display computer access system, one for the alternate keyboard and the other for use by the application program. Examples of current systems that use a separate display include the Express III (1), Long Range Optical Pointer (LROP) (2) and the Trine System (3). The limitation of a dual-screen system is the additional cost of second display and the lack of portability when a portable computer system is preferred.

There are several reasons the dual screen approach has dominated transparent computer access techniques. First, most application programs that run on the IBM PC take full control of the standard display resources. It would be impossible for an alternate keyboard display to reside on the same screen while the application program is running since it would constantly be writing over the alternate keyboard. Even if the alternate keyboard were constantly redrawing itself it would block potentially important information displayed by the application program. Another problem is the number of screen modes available on the IBM PC on which the alternate keyboard would need to be displayed. Many of these modes only provide character-level graphics capability, limiting the resolution of showing where the user is pointing. Current transducers that detect the user's pointing cause additional problems. Many of the transducers are dependent on their own display technology, which is incompatible with standard video and LCD displays found on computer systems.

PURPOSE

This project explored the ability of multiplexing the standard CGA display of the IBM PC for use as an alternate keyboard while also being used to display information from the application program. This requires suspending the operation of the application program, saving the current mode and contents of the screen, and drawing the keyboard image on the screen. After keys have been selected from the keyboard and before they are sent to the application program the keyboard must be removed and the application screen information restored. Figure 1 shows a person using a headstick to select keys from a computer keyboard. The individual looks at the keyboard to type, and then to the screen to see the results. The Trace One-Screen program functions similarly (Figure 2), with the user raising his head slightly to remove the keyboard image from the screen and redisplay the application program.

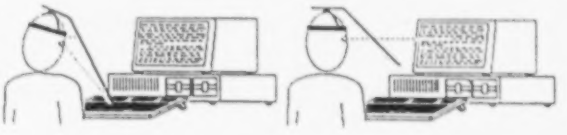

Figure 1

Figure 2

Keyboard Design

One of the most important design considerations is the ability of the user to functionally use an application program being multiplexed on the same screen with a keyboard. The user in this computer environment is interacting with the application program in a series of tasks of entering information into the computer and then watching to see the effect. When the user wants to begin to type into the application program they first point toward the screen; the application program is suspended, and the keyboard image appears on the screen. The user selects keys from the alternate keyboard and then points off the screen to allow the keys selected to be sent to the application program. When the user moves off the keyboard, the application program is restored to operation and the keys are given to the application program, allowing the user to see their effect. In this situation the user cannot instantaneously see the effects of the selected keys on the application program. While this may not be a big problem when typing in words into a word processor, it becomes a more difficult problem when the user is transversing a menu or scrolling through a document with arrow keys.

Screen Multiplexing

Whenever the user points toward the screen the alternate keyboard appears. Once the keyboard appears the user can return to the application program by pointing off the screen through the break in the top and bottom borders (see Fig. 3). The user can peek at the application screen by moving the pointer

through the break in either the left or right borders. The rest of the border constrains the user from moving off screen. This assists in the selection of keys near the edge of the screen, since people tend to overshoot targets (4) when they are moving a pointer to the target area (in this case a key). Without the border the overshoot would typically cause the user to point off screen, removing the keyboard and disorienting the user about where they are pointing. The border therefore constrains the user from inadvertently moving off screen and allows them to continuously monitor their pointing movements.

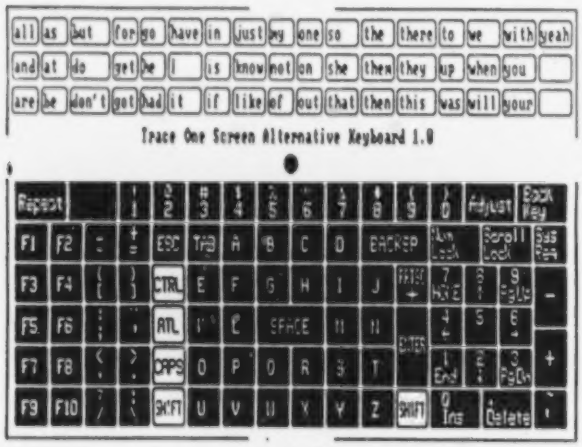

Figure 3

Three features make the software particularly interactive and usable. First, the screen switching mechanism is almost instantaneous, allowing quick change between the application and the keyboard. Second is the ability to look at the application program without sending the keys contained in the keyboard buffer. This allows the user to peek at the application screen to see where they are with in the application program without actually allowing it to run. Finally, a repeat key allows the user to have a key repeated at a user-specified rate as they watch the effects on the application screen. The repeating key is released when the user points back toward the keyboard. This is useful when the user wishes to scroll through a document or delete a string of characters.

Key Selection

Keys are selected on the alternate keyboard by holding the pointer on a key for a user-adjustable period of time. If the user continues to hold the pointer on a key it will be repeated automatically. The repeat time is also adjustable by the user; it can effectively be defeated by setting the repeat time to a large value. Each time the user selects a key the spot used for indicating where the user is pointing is temporarily removed and a tone is sounded. This provides the user with both auditory and visual feedback of key selection. The audio tone can be turned off if it is distracting to the users or others in the working environment. As keys are typed they appear on a display line just above the keyboard so the user can easily see the keys they have typed into the buffer. If a mistake is make the user can correct it by deleting the key from the key buffer before it is sent to the application program.

The IBM PC has four modifying keys on the standard keyboard (Control, Alt, Left and Right Shift keys) that are held down simultaneously with other keys to change their function or character. Since the pointer only allows one key at a time to be selected on the alternate keyboard these keys must be effectively held until the next key is selected before they are released. The modifying keys can be held only for the next key stroke or can be locked on for a series of keystrokes. This is called tri-stating the switches, since the switches can take on one of three states; Off, Effect next key only or Effect all subsequent keys until turned off. The states are manipulated by sequentially selecting the modifying key. The state of the modifying key is displayed above the output key display.

To increase the effective typing rate the 50 most commonly used words are displayed and can be directly selected by the user. The words appear on the top third of the keyboard image.

Adjusting Keyboard

The user can adjust key selection and output parameters in an adjustment menu. The ADJUSTER key on the keyboard switches the display to a adjuster menu. From the menu the user can change values by pointing at keys to either increase or decrease values or to turn Boolean variables on or off. Currently programmable variables are:

Key Selection time (.18 - 2.00 seconds)
Key Repeat time (.37 - 4.00 seconds)
Key Selection Tone On/Off
Movement Amplification (1-9)
Output Typing Rate (range:1-99 keys/second)
Output Repeat Rate (range:1-99 keys/minute)

CONCLUSION

The program developed demonstrates the ability to produce a one screen alternate keyboard for IBM PC DOS desktop computers and their compatibles (including portable computers with LCD displays). This development will help reduce hardware costs of computer access systems and provide a link to portable MS-DOS computers for portable writing and computer access systems. The program is currently compatible with Microsoft Mice and compatibles and with the Long Range Optical Pointer. Other pointers which do not already emulate the Microsoft Mouse will be adapted for use with the software as they become commercially available.

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ACCESSIBILITY OF OS/2 FOR INDIVIDUALS WITH MOVEMENT IMPAIRMENTS: STRATEGIES FOR THE IMPLEMENTATION OF 1-FINGER, MOUSEKEYS, AND SOFTWARE KEYBOARD EMULATING INTERFACES USING DEVICE DRIVERS AND MONITORS

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ABSTRACT

The Microsoft/IBM Operating System/2 (OS/2) offers new advantages in accessibility over PC-DOS in the implementation of special software, such as 1-FINGER, MOUSEKEYS, and Keyboard Emulating Interfaces (KEI), to allow individuals with movement impairments to use the computer. OS/2 accomplishes this by providing a better means to simulate user input of the mouse and keyboard. First, application programs must get user input via the operating system kernel rather than directly via the hardware. In turn, the OS/2 kernel relies on device drivers instead of interacting with the hardware to get user input. Therefore "fake" user input for the operating system kernel and the application programs can be achieved by re-writing the device drivers to provide the functionality of the special input software. OS/2 also provides a facility called "monitors" which allows programs or "processes" to monitor the data stream of a device driver in a manner so that the monitor can either remove, insert, or modify the information passing through the device. In addition, since OS/2 provides true pre-emptive multi-tasking, it allows these alternative input programs to run concurrently with the application programs without interfering with them or other monitor programs.

However, there are some restrictions imposed with OS/2. A monitor is limited to a screen group, which means that if an alternative input program is to work in all the screen groups, then monitors need to be registered in each group. Another restriction is that programs which run in the OS/2 compatibility box will not be able to benefit from the alternative access programs that use monitors or rely on the multi-tasking ability of OS/2 since both the monitors and the multi-tasking processes are halted when running a program in the compatibility box (necessary if you want to run standard PC-DOS programs). This means that the only way to get alternative access programs to work with OS/2 in both the protected mode and the compatibility box will be to re-write device drivers.

Nevertheless, OS/2 provides a much better environment to implement special input software than the method of using terminate-and-stay-resident (TSR) programs in PC-DOS, where the TSR's constantly collide with each other over control of the hardware and user input, and where application programs would access the hardware directly.

INTRODUCTION

Microsoft/IBM Operating System/2 (OS/2) is a very complex operating system. There are many new concepts and terms that need to be understood before effective discussion on the merits and problems of OS/2 in regard to accessibility by individuals with disabilities can take place.

Protected Mode Operation

OS/2 utilizes the protected mode capability of the Intel 80286 microprocessor. In this mode, the processor is able to support true pre-emptive multi-tasking. Pre-emptive means that even if a program wants to keep control of the CPU execution, it cannot. Programs are forced to share CPU time with other programs running at the same time without even being aware of the switching.

Process

An application program is one "process", which may have several threads running at the same time, and may have ownership of resources such as the screen and serial ports. There can be more than one instance of a program running at a time (i.e. two instances of a Lotus 123 program running). Then each instance of the program is a different process, with only one copy of the code in memory.

Threads

In protected mode, the processor can run different pieces of code all at the same time. In reality, it is only running a "thread" of code at a time, but threads are stopped and started based on a priority system in a preemptive manner..

Screen Group

Program(s) run in a "screen group." Programs in each screen group send screen output to a virtual screen and get user input from a virtual keyboard and mouse. The screen group which is "active", displays its output on the physical display and the input from the physical mouse and keyboard get directed to it.

Compatibility Box (real mode operation)

The "compatibility box" is where real mode DOS applications can be run and it is itself a screen group. While in the compatibility box, all protected mode screen groups are inactive, and likewise, while in the other protected mode screen groups, the program running in the compatibility box is inactive.

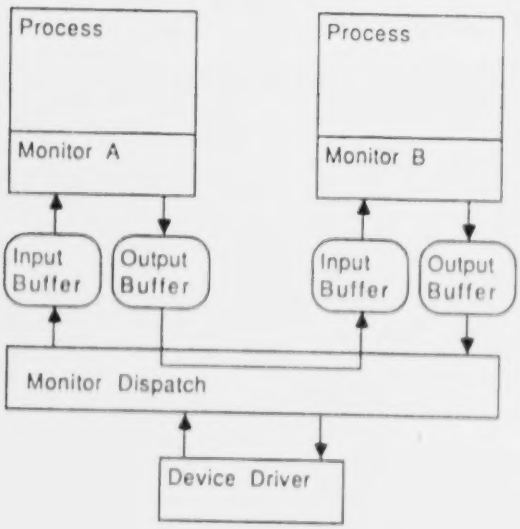
DISCUSSION

Because of the structure of OS/2, there are many different approaches to implementing programs such as 1-FINGER, MOUSEKEYS, and a software KEI, and to gaining different levels of accessibility.

Monitors

OS/2 provides a feature called "monitors" which allow programs to register a piece of code that monitors the data flow of a device driver. The device driver passes on data to the "monitor dispatch" unit. This unit passes the data to the input buffer to a monitor. The monitor then gets the data packet from its input buffer, and can either do nothing and write it to the output buffer, can inhibit it by not writing it to the output buffer, or can modify it and write it to the output buffer. The monitor, since it is another thread, can also

actually write a data packet into its output buffer anytime, even if it never received a data packet from its input buffer. In this way, it can inject data packets. The monitor dispatch unit (it is also an another thread) simply takes data packets from the output of the monitor and either passes it on to another monitor (if there is another one) or passes it on to the system.



If there is more than one monitor attached to a device driver, then they are passed the data packets from the device driver in the order that they are registered. Therefore, for a program like 1-FINGER which needs to be the very first monitor that gets data packets from the device driver, it needs to always be the first monitor. Other monitors that provide functions like keyboard macros, or MOUSEKEYS can be in other positions. A monitor that only injects data packets, such as a KEI, must go before keyboard macros or mousekeys, and after a 1-FINGER monitor.

Device Drivers

To allow OS/2 to run on different hardware platforms, OS/2 depends on device drivers. OS/2 has a defined protocol between the device driver and the operating system kernel, so the underlying hardware can be different as long as new device drivers are written for them which support the minimum features of the standard device, and conform to the established protocol.

This helps in providing alternative access since the kernel does not know if the actual data passed from the device driver was really generated from the hardware or not. In addition, there is also the ability for a program to communicate with a device driver, and so a program could pass "simulated" data to the device driver. The next time the device driver is asked for data, it can pass on the simulated data instead of real data.

Advantages Over PC-DOS

OS/2 has the advantage over PC-DOS in that there is a much clearer and less catastrophic way for more than one program to not only reside in memory at the same time, but to be executing intermixed, without cooperative pseudo-multi-tasking.

OS/2 also provides an orderly was to hook into the data path of input devices such as the keyboard and the mouse. There is no longer this need to be careful of the order of loading TSR programs.

OS/2 also provides ways to inject multiple events into the data stream of a device driver. In PC-DOS, it was impossible to simulate new or different keystrokes for the keyboard interrupt since the keyboard interrupt routine looked directly at hardware.

OS/2 also provides strict guidelines such that other programs can't disable the access programs.

Disadvantages Compared to PC-DOS

A disadvantage of OS/2 as compared to PC-DOS is that the main features of OS/2 (e.g. multi-tasking, monitors, etc.) are not available in the compatibility box. Therefore, any solution which relies on the protected mode features of OS/2 will not work in the compatibility box, and the traditional PC-DOS approaches will have to be used. However, these approaches may no longer work since programs which are timing dependent, "know" something about DOS, or write to absolute hard disk location will not run. Unfortunately, this includes many of the current access programs.

CONCLUSION

Since Microsoft/IBM Operating System/2 is a completely new system, the old access programs that worked under PC-DOS no longer work. However, OS/2 does provide some much needed features that make alternative input programs much more effective and easier to implement in the future. Except for PC-DOS programs which must run under the compatability box, simulation of all the input devices are possible and in an easy manner. Providing complete access in the compatibility box requires the difficult task of re-writing device drivers. Overall, OS/2 makes the days of the battles between terminate-stay-resident programs of the PC-DOS days a problem of the past.

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